THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FOURTH SERIES.]

No. 114. JUNE 1877.

XLIV.—*On the Variability of the Species in the case of certain Fishes.* By Dr. V. Fatio*.

Several authors have of late years demonstrated the influence of the surrounding medium upon organisms, and indicated in various particulars the variability of the species.

The *struggle for existence* and *natural selection* especially are no longer subjects of doubt with many zoologists.

A change in such or such a condition of existence almost always superinduces a parallel modification in such or such an organ, the mode of action of which is more or less affected; and this first translation of the external influences necessarily draws after it corresponding disturbances in several other parts characteristic of the species.

Darwin, in his work on the Origin of Species, gives the name of *correlative variation* to this kind of reaction of a modified part upon other corresponding parts, and demonstrates sufficiently by numerous examples that the changes which have taken place in an individual may be reproduced and multiplied by heredity. Häckel distinguishes direct or immediate influences, acting upon the individual, and indirect or mediate influences, which only become perceptible by heredity. This latter author even devotes a whole chapter of his 'Natural History of Creation' to this subject, under the title of "Laws of Adaptation."

* Translated by W. S. Dallas, F.L.S., from the 'Bibliothèque Universelle: Archives des Sciences,' tome lviii. p. 185.

Several naturalists have already more or less studied and described the series of transformations which, under the influence of the variability of the conditions of existence, have gradually modified, sometimes the actions, and sometimes the forms of certain animals and plants, often sufficiently to render unrecognizable the traits of relationship which ought to unite individuals which, at the first glance, are completely different.

The particular point to which I desire here to call attention will not, therefore, find its interpretation in an entirely new order of ideas. However, as each new stone added to the edifice of an opinion cannot fail to be of use, I think I ought to take advantage of some of my most recent observations to expound succinctly some reflections which have by little and little grouped themselves in my mind since I have investigated the Swiss Vertebrata and their variability under different conditions.

A conscientious zoologist can no longer establish new species so easily as heretofore. Many apparently distinctive charaters fall to the ground or lose more or less of their importance before a thorough study of possible modifications. Each character calls for serious discussion; it is necessary to seek, if not the limits of variability, at least the points which, under such or such an ensemble of appreciable conditions, seem to be the most solid.

It is, in fact, to the narrowness of the limit ascribed to the species in the old definitions, and to the often inconsiderate multiplication of specific types apparently different, that we owe in a great degree the confusion which now reigns either in certain parts of classification, or in the minds of many people who seek, in different directions, the foundation of truth.

The species is very difficult to define or to limit; for a group of individuals similar to each other, exactly like a certain individual, attributed to such or such a species, seems to be nothing more in reality than *the actual expression, under certain given conditions, of a form taken upon such or such a step of the animal scale*, or upon such or such a branch of a genealogical tree*.

* The subject of which alone I wish to treat here is too restricted to lead me to launch out now upon the hypotheses as to the derivation of the original types. Science in general and palæontology in particular cannot yet offer us any definitive solution of this question. I have nothing to do, therefore, at present with the question whether there have been several animal scales, or whether a single scale has been at first composed

Whether it belongs to a single primitive tree or to one of the descendants of the latter in the forest of beings, the bud, species or variety, which terminates a branch must always possess the power of yielding more or less to the exigencies of a variable medium, and of being able to produce thus new modifications of greater or less importance, themselves endowed, in their turn, with greater or less variability and vitality.

Most authors who desire to give an absolute definition of the species, generally invoke, as evidence of stability, the difficulty of intercrossings between distinct species, and the comparative sterility of the hybrids thereby produced, as also the facility with which, on the other hand, the races derived under our eyes from a single stock multiply together. These difficulties, however, which are often exaggerated, frequently seem to result from the desire to unite, for certain advantages, organisms endowed with useful qualities of too opposite a nature. In the two cases we are at a very different distance from the parent form; it is necessary, as Besnard has already indicated, to be able to make one's choice, or to return further back in the ramifications of the genealogical tree. It is probably for an analogous reason that it is usually the lower types that present most possible modifications or combinations. A longer duration of the influences, by more profoundly altering the organisms, evidently diminishes the sentimental attraction, if we may so call it, that a similarity of appearance must necessarily favour, and at the same time renders a perfect combination of the organism of the two individuals selected less easy to be effected in a manner sufficiently complete to become productive.

It is impossible not to see here the existence of two general laws opposed to one another and constantly struggling one against the other, and which, according as they are called by circumstances to predominate over one another, maintain the species within relatively immutable limits, or, on the contrary,

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of a single step. In other words, I cannot decide whether the genealogical tree of living creatures was planted with all its smallest branches, as Agassiz thought, or whether a primordial cell, in place of a seed, originally gave birth to a genealogical tree which, at first an aquatic plant, gradually extended its branches upon the solid ground, and, growing larger and larger, put forth all the branches which now-a-days constitute the totality of the known and unknown organisms on the face of the globe, according to the views of some disciples of Darwin, Rolle, Häckel, and others. It matters little to me, in fact, in the ascertainment of the variability of an existing species, whether I assume the existence of one or several seeds, whether I see a single tree constantly increasing in size, or perhaps still believe in the existence of a whole forest of genealogical trees, sprung from the seeds of a single plant, but from germs which have fallen successively under different conditions.

urge it towards constant variability. *There seems to exist a law of hereditary resemblance which tends always to keep to the specific type, and a law of variability by adaptation, destined, on the contrary, to modify every organism with the object of fitting it to new conditions of existence.*

Differences and variations of medium being incontestable, it is irrational to try to prove the stability of the species by closing our eyes to one whole side of the question, citing only those cases in which the first of the above laws has gained the victory, either directly or by return or atavism. *In the study of the variation of the species, in order to be impartial, we must, I think, commence by fully recognizing the importance of the first of the two opposing laws, and freely accepting it, from the first, as a sort of brake preimposed upon future modifications.*

While attributing great variability to the species, we must not, however, I think, refuse proper names to all the more or less different forms of creatures in various classes. Natural history and classification have need of these distinctive designations, which become, as it were, so many heads of chapters and *cadres* for observations. Now-a-days, indeed, there are many distinguished naturalists who see no inconvenience in complicating the binary nomenclature by the creation of a special name for each variety. The accumulation of names is not, in fact, dangerous, if we always take care to indicate the relations or affinities which bind together two forms nominally separated.

It has been said that it is the richest genera which furnish the greatest amount of examples of variation by adaptation; this observation would, I think, be better represented by the very simple remark that it is the largest genera which include the most false species founded upon local varieties.

I have often been struck with finding in several large genera a species at once much more widely distributed, and much more subject to vary, than the others, even in a very restricted space. The red frog, in the genus *Rana*, and the common toad in the genus *Bufo*, among the Batrachia, as well as the trout in the genus *Salmo*, and the roach in the genus *Leuciscus*, among fishes, may, among others, furnish us with striking examples of cases of this kind.

Such species, a sort of predominant branches, must be regarded as the parents or stocks of several other so-called species, more or less deviated, in different directions and in different countries; they are the type and, as it were, the centre of a natural group of forms, all of which resemble them in different degrees.

Although called upon to vary, more or less, and with time, in certain countries, when in spreading it has met with new exigencies, the species may nevertheless remain relatively fixed, or vary comparatively little in the same locality or in analogous media, so long as the conditions are not sufficiently modified. This is what led the illustrious Cuvier to say, and up to a certain point with justice, "Experience seems to show, on the contrary, that, in the actual state of the globe, varieties are confined within very narrow limits; and so far as we can go back into antiquity, we see that these limits were the same as at the present day."

I have already several times recognized and indicated, in certain widely distributed species belonging to various classes of our Vertebrata, nascent divergences in some part or other of the animal. These variations, more and more strongly marked until they reach adaptation through the persistence of the influences and heredity, constitute what I call *tendencies*, or the origin of new bifurcations upon a genealogical branch. Often perceptible in certain individuals in a very limited field of observation, they increase more and more in other countries with the augmentation of the first small dissimilarities of condition, and thus advance towards *temporary maxima*, which in various places have received different specific names.

The origin of these divergences may be, according to circumstances, attributed to a persistence of the characters of youth, or to the predominance of the distinctive features of one or the other sex, or to the reproduction by heredity of a quasi-accidental anomaly, or, again, in consequence of the struggle for existence, to new exigencies of the conditions of life. I have particularly indicated, in the number of the 'Archives de la Bibliothèque Universelle' for September 1876, the coexistence, in the waters of the Lake of Geneva, of three very distinct tendencies in the forms of the roach (*Leuciscus rutilus*). Each of these three varieties (deep, elongated, or thick) already indicates, with a primary modification of the general form, more or less strongly marked correlative deviations in several of its characters.

Without going beyond the restricted bounds of our own ichthyological fauna, I might cite several other cases of varieties of one and the same species living thus almost side by side, although kept distinct by exigencies of medium, which are often badly interpreted. It may suffice for me, in this connexion, to refer to the example of our freshwater trout, which, according as it is more or less confined to small streams or to the deeper waters of our lakes, presents a facies so diffe-

rent as to have passed hitherto for two perfectly distinct species in the eyes of most ichthyologists. It is well known that the size of the basin and the relative abundance of alimentation have much influence on the dimensions of the animal. The little brook-trout, which most zoologists still distinguish under the name of *Salar Ausonii* (on the ground of its small size, its thickset form, the shortness of its nose, the comparatively larger dimensions of its eye, and some peculiarities in its dentition), is, in fact, in my opinion, nothing more than a form of the great trout of our lakes, which is called, according to circumstances, *Trutta lacustris*, *T. Schiffermülleri*, *Fario Marsiglii*, or *Salmo lemanus*. Most of the characters proposed for its distinction are those of the early age of the fish. In a small stream the trout, which cannot grow for want of room, arrives at an advanced age retaining more or less the characters of infancy. It would be still more surprising to meet with trout of 30 lb. in a few inches of water. Moreover I have already remarked several times that the fishes—such as the perch (*Perca fluviatilis*) and the chub (*Squalius cephalus*), for example—which inhabit the cold and poor waters of some of our small elevated lakes in the Alps, also usually retain several of the characteristic features of youth, their size also being small.

Many naturalists, misunderstanding the natural affinities which bring together allied species, although at present perhaps separated by very important geographical boundaries, have gone so far as completely to deny the production of races in organisms in a free state. Faivre, among others, following Godron, unhesitatingly maintains that variations and races are very rare among plants and animals in a wild state. This author appears to me, in particular, to place himself in flagrant contradiction to direct observation when he says, for example, "The races found under these conditions are exceptional, to such an extent that many naturalists do not hesitate to call in question their existence."

Wallace, holding an exactly opposite opinion, published in 1858 a very interesting memoir on the tendency of varieties to depart indefinitely from the original type. Trautschold also, in 1861, drew a somewhat different conclusion from analogous observations: according to the latter, "The varieties which unite two species have also the power of modifying themselves in more than two directions; but the result obtained by the changes effected in a third direction must not be regarded as a simple variety, it must take rank as a new species." The first author perhaps exaggerates, while the second may seem to wish to specify a little too much; how-

ever, it none the less appears, from what they say, that to them, as to me and many others, variability is becoming more and more evident.

A variety duly ascertained may be regarded, according to the point of view that we take up, *either as a bond between two so-called recognized species, or as a tendency towards the creation of a new form.*

The question as to the existence of a limit to the variability of the species appears difficult to settle; nevertheless it may be remarked that, for the perpetuation and constant augmentation of a deviation at one point, the gradual establishment of a certain necessary equilibrium in the correlative variations is required. A rapid modification of an organ which, in consequence of internal incompatibilities or external contrarieties, is not followed quickly enough by corresponding changes in other parts of the organism, will almost always superinduce either an arrest of the transformation in this direction, or the extinction of the new divergent form, whether we regard the latter as a species, as a variety, or simply as an abortive shoot on a genealogical branch.

A great number of observations tend to prove more and more that, in the struggle for existence, natural selection always gives the victory to the best organized, and that the case of the strongest is always the best. Influenced in various directions a species will give origin to several more or less different offshoots; and only those will long persist which may be sufficiently strong to bend, *without excess and in an equilibrated manner*, to the various exigencies of different conditions.

There is therefore a limit, in a certain sense; but this limit, being due to a rupture of equilibrium, and often accidental, is wider or narrower for the different varieties; and each of the latter, by departing more and more from the type, always runs the risk of meeting reverses in some part or other of its organization when in a false direction.

A natural barrier, even when very narrow, sometimes suffices to establish differences, striking enough at the first glance, between two allied forms. If, in the examination of a great number of individuals taken under the two conditions, we can still perceive the transitional steps which explain the series of transformations, we must, I think, for the time, regard these two still divergent or parallel forms only as local races of the same species; but, on the contrary, if one or several important steps are wanting in the scale of comparisons, we may regard these two opposed forms as different species, until evidence to the contrary is produced.

These first two cases have often occurred to me in the comparative investigation of the fishes in the Swiss lakes of the north and south of the Alps. But there is a third case, with regard to which I must here say a few words—namely, the rare case in which we find suddenly, and as it were by chance, among a great number of individuals of two derivations, and sufficiently constantly different to appear to belong two species, an individual which, in one of the geographically separated forms, resembles the other form in all its characters, so as actually to be mistaken for it, and thus betrays the heredity or identity of origin.

I may cite, as a curious example of this last case, the discovery that I made in the lake of Lugano of a bleak (*Alburnus*) which, south of the Alps, perfectly recalls the form proper to our representative of the genus north of that chain. It is well known, in fact, that hitherto all ichthyologists have recognized the bleak of the Ticino and of Italy as completely and specifically distinct from that which inhabits the waters which have their source north of the Alps. Now the specimen in question, found among hundreds of similar individuals of *Alburnus alborella*, presents, both in size and coloration, and in its various forms and proportions, nearly all the characters regarded as distinctive of our *Alburnus lucidus*. Never before has such a bleak been noticed as inhabiting the Italian waters; and it would be very difficult for me to explain under what influence this reversion can have been produced. However, in presence of this revocation of consanguinity, I can now do no otherwise than regard *Alburnus lucidus* and *A. alborella*, which at first sight are very distinct, as two races, the one northern, the other southern, of one and the same species. Although it would appear that we must go back very far to find the epoch at which these two supposed species lived under the same form, under identical conditions, it none the less seems that we have to do here with *a complete case of atavism, though of very distant date.*

The partisans of the variability of species have laid much stress on the study of the variations of domestic animals. Deformations produced accidentally or by artificial selection are, in fact, comparatively easy of demonstration in subjects necessarily submitted to our observation; but the appearance in free creatures of modifications superinduced by natural selection, or at any rate by influences independent of the will of man, being always more difficult to seize, it seems that the study, under natural conditions, of a divergence of any kind in any organ must also possess its interest and value.

Let us confine ourselves now to the study of the modifica-

tions introduced by circumstances into the organs of prehension, and endeavour to trace as far as possible some of the correlative compensations necessarily superinduced in other parts of the organism. We may even reduce our field of observation to the investigation of these organs in certain fishes, as indicated in the title of this note.

To attain the same end, nature must sometimes employ, according to circumstances, very different means; moreover, even with identical means, it often happens that, under different circumstances, the correlative modifications are not effected alike, sometimes in different individuals of the same species, sometimes in the different parts of the same individual.

The organs of prehension, so varied in the animal kingdom, being, in the fishes, represented by the mouth alone, one can easily understand the influence that may be gradually exerted upon the arrangement and proportions of this buccal cleft in the first place, and then upon the whole organization of the individual, by the modifications introduced into the actions and "*gymnastic*" of the animal by the necessarily different mode of prehension to which it must adapt itself in order to procure its nourishment in one condition or position or another —above or below it, at the surface or the bottom of the water, for example.

A mere glance at a few marine fishes will amply suffice to show us many different aspects of the buccal pieces appropriated to one mode of prehension or another; we have only to consider, for example, the comparative forms of the body, or of the limbs and jaws, in the genera *Xiphias*, *Histiophorus*, *Centriscus*, and *Belone*. But under conditions more like those of our own country, the freshwater species may also show us various forms of the mouth adapted to different uses. As I shall have to revert to these, I shall confine myself here to referring *en passant* to the case of *Toxotes jaculator*, which takes its prey at the surface, and often even provokes the fall of the insects on which it feeds by projecting a drop of water at those which are placed above the liquid. For this purpose this fish has the lower jaw considerably prominent and turned up, and at the same time the fins placed far enough back to allow the entire head of the animal to be easily kept raised into the air. If I cared to go beyond the class which particularly occupies our attention I might also recall the fact that those birds which are condemned, without swimming, to seek their nourishment at the bottom of the water, have the legs, the neck, and the beak all greatly elongated; whilst in those which, like the snipe, for example, are called upon to rummage beneath them, not at the bottom of the water, but only in

the firm ground, the legs, naturally, do not follow the beak in the necessity of elongation. It would be easy also to cite other examples already indicated among the Mammalia, especially in certain races of cattle; but we will not go beyond our self-imposed limits.

My business is only to demonstrate *that the general laws of adaptation which presided over the formation of types, continue always to exercise their influence upon all individuals in different conditions**.

Moreover I think that, in such investigations, we must not seek too far for our points of comparison; for, with its purpose and its organization, each type also appears to have its own tendencies to variability, may be as a predominant direction for the possible modifications in a certain medium. In other words, *each species, or each group of allied forms, appears to me, in our country and under certain conditions, to vary preferently towards such or such a given point.* The parts more easily influencible constitute for the species at once the weak point from the side of classification, and the strong point as regards facility of adaptation, force of resistance, and power of extension.

It is evident that, according to the nature of the persistent exigencies of the medium, it will be sometimes one and sometimes another of the organs of relation that will be first called upon to become modified; but it is no less true that *in each species we shall always find, in a given medium, a particular character which is more subject to vary or more prompt to become modified.* The exact determination of the character which, being the first modified, has reacted upon all the others, has always appeared to Darwin excessively difficult; and yet *it is upon the study of the variable preponderance of the*

* The history of our globe, painfully elaborated by geology and palæontology, seems to be more and more in accord with zoology and physiology upon this point. After leading us, in the forms of organisms, through a whole series of successive modifications corresponding to the different geological epochs and the different exigencies of the media of the latter, palæontology has shown us, in fact, how, in sequence of a change of stratum and of conditions of existence, many forms have often disappeared, whilst some only continued to exist. In consequence, perhaps, of a too rapid transformation of the conditions of life, those only have been able to subsist which were sufficiently prepared or modified to be able to sustain a rupture of equilibrium fatal to many others. Although we cannot always so easily understand the sudden appearance in a new stratum of an entirely different fauna, I do not doubt, in common with some authors, that by gradually piercing the obscurity which necessarily envelops the variability of creatures long since lost, we shall succeed in explaining these apparently sudden and complete changes without having recourse to the necessity of a new creative intervention.

different characters that the more or less rational establishment of genera and species in great part depends.

The great functions of life, nutrition and reproduction, naturally govern this selection of the more or less influencible parts. According as the preservation of the individual or the perpetuation of the species is brought into question by the changes of medium, it is evidently also among the external organs which serve one or the other that the modifiable character the best fitted to effect the adaptation will be selected. The degree of complaisance, or, on the contrary, the exigencies of these two essential functions, allow more or less latitude to such or such an organ which brings them directly into relation with the outer world.

Although only considering the question from one of its sides, and devoting ourselves more particularly to the investigation of certain parts specially useful for the preservation of the individual, we nevertheless cannot here help recognizing, as it were, *a brake imposed upon the too rapid modifications of one organ by the exigencies of another—may be, as a new struggle in view of a more or less stable equilibrium, until perfect adaptation.*

As I have said, the whole organism of an individual must be able to bend itself to the more or less sudden changes necessitated in the modification of gestures or habits by the apparition of a new exigency, and follow in an equilibrated manner the transformations effected in the organ of relation which was first called upon to vary.

If we were to select as examples of struggle between external and internal organs in certain fishes, on the one hand, the eye or the mouth as displaying the appetites, and, on the other, the air-bladder as above all subjected to the conditions of temperature or pressure of the medium, we should soon find several curious cases of ruptures of equilibrium, both accidental and normal, and injurious, sometimes to the individual, sometimes to the species.

Among others, we know that in the perch (*Perca fluviatilis*), suddenly drawn up by the line from the depths of our lakes, the air-bladder, being too rapidly transported from a considerable pressure to a much smaller one, is suddenly distended in an extraordinary manner, projecting itself into the mouth, and sometimes even driving out a part of the digestive organs. We also know that the pike (*Esox lucius*), when carried, by its voracity, too rapidly from the deeper towards the superficial strata of the water in pursuit of prey, is forcibly retained at the surface by an exaggerated development of the swimming-bladder, and often perishes in consequence of this injury, which in this case is quite voluntary.

In these two instances a too rapid change of conditions leads to a rupture in the equilibrium of the organism, and often involves the death of the individual. The elastic fibres of the air-bladder, too rapidly distended, can no more resume their empire and exert a sufficient compression; and this would not have happened in consequence of slower and more gradual transitions.

But the principal purpose of the air-bladder is not, apparently, to condemn the species to an invariable habitat; the function of this organ is rather, by pressing against the backbone, to keep the individual in the normal position proper for its preservation. Other examples will enable us to understand the importance of this function from the point of view of the preservation of the deviated race, and the comparative action either of certain organs of relation upon the bladder, which is at once a moderative agent and one of equilibrium, or of the latter upon the position of the individual, and thereby upon some of its external forms.

Every one is acquainted with the goldfish or gold carp (*Carassius auratus*), which normally exhibits oblong forms like those of the carp, but to which the Chinese have found the way to give the most curious shapes. By cleverly taking advantage of the smallest accidental deformations, and instigating and exaggerating monstrous tendencies by subjecting the fish to abnormal conditions, the adroit inhabitants of the celestial empire have actually succeeded in manufacturing goldfish with double and triple fins, with a quasi-spherical body, and with the eyes excessively prominent, or often borne upon a longer or shorter pedicle *.

M. Carbonnier, of Paris, has already remarked that the equilibrium is very unstable in the quasi-globular varieties of the goldfish, and that, after arriving at a certain age, many of the young fishes of this form must perish, from being forcibly kept in a position which scarcely allows them to feed, some of them with the head turned upwards, many with the head turned down. Two years ago I had the opportunity of seeing in the aquaria of this learned observer several adult globular goldfish with more or less prominent eyes, in which the very different arrangement of the mouth particularly attracted my attention. Two of these appeared to me to be especially interesting.

One of them, with a spherical form and a comparatively short backbone, presented a very turned-up snout and a very

* It is believed that this last variety, which has received the name of the telescope-fish, may be produced by causing the light to reach the fish only from a single point.

oblique mouth; it could hardly take any food, except above it or at the surface of the water. The other, which was also globular and had a very oblique mouth, but with a still shorter backbone, remained completely turned over on its back, with its large belly upwards. The latter, it seems, had commenced by being like the other; then, at a certain moment, the air-bladder being more and more displaced by the pressure of the vertebral column, and the centre of gravity shifted, the animal was completely turned over.

It appeared that the reversed goldfish, when food was offered to it after a long fast, could still take nourishment by great exertions, and that, under the influence of this temporary counterpoise in the digestive tube, it could maintain itself for a certain period, and by considerable efforts, in a quasi-normal position, but only to allow itself soon afterwards to be turned upside down again by the air-bladder.

In consequence of a compulsorily abnormal position, the head and then the backbone had gradually been deformed, until the arrival of a moment when, the equilibrium being broken and the fins being unable any longer to struggle sufficiently, the air-bladder intervened to put a forced term to the primary external modifications.

I have for some time observed, in one of the aquaria of M. E. Covelle at Geneva, a very curious pathological case, to a certain extent parallel to that of the goldfish, in an adult rudd (*Scardinius erythrophthalmus*). For about three months this fish has remained at the bottom of the aquarium, always lying upon its right side. The air-bladder, which can no longer press against the backbone, now forms a very apparent swelling upon the left side. In consequence of a paralysis produced, after a fall, in the anterior dorsal muscles of the right side, there took place, by degrees, first an increasing atrophy of the above-mentioned right lateral muscles, and afterwards a gradual deviation of the vertebral column. At present the paralysis has reached the level of the ventrals, and the caudal portion of the body is recurving by little and little towards the back. Nevertheless this fish can still, by great exertions, like the reversed goldfish, take and digest the food that is put from time to time within its reach. Although meagre, it appears to be in very good health, except for its paralysis; its respiratory movements, although rather rapid, are comparatively normal; and the free pectoral fin, during this compulsory repose, nevertheless moves continually, as if to ventilate the branchiæ or agitate the water in the vicinity of those organs. The coloration of the body and fins is perfectly good, and does not seem at present to indicate any impoverishment.

While the air-bladder, which presses against the left flank, keeps the animal lying down, and it is by this means more and more twisted, the eyes are subjected to very different conditions and to very unequal use: the right eye, applied to the bottom, remains in its normal vertical position with regard to the axis of the head; but the left eye, thus condemned to look always upward, turns more and more in order to see round it as much as possible in a horizontal direction. The fish has not been three months in its present position; and yet the globe of the eye, more and more elevated on the frontal side, has already made more than one eighth of a turn, or an angle of 45° to its normal position. Without desiring to make too forced a comparison, one cannot help thinking of the Pleuronectid fishes, which ordinarily repose upon one side, and in which, as is well known, the two eyes, which are at first symmetrically arranged, gradually come together, during development, upon the same side of the animal.

Lastly, from the study of the pathological case of this fish, we may further draw a fresh proof of the fact, which has already been several times demonstrated, *that the will is never free, or that a deformation, even when accidental and ever so small, seems always to be multiplied, in the direction of variability, by an unpremeditated will.* In fact, if, after having struggled in all directions to take its food, the rudd by chance falls upon the left flank, the disagreeable pressure exerted by the bottom upon the displaced air-bladder, and the instability given to it by the convexity of this side of its body, invariably urge the fish to quit this position (which nevertheless would tend to reestablish equilibrium in its organism), and to make effort after effort until it succeeds in replacing itself on its right flank, in a position which tends constantly more and more towards deformation.

Led by such data, either as to the effect of deformations of the mouth, the head, and the body upon the air-bladder, or inversely as to the influence of the latter upon external form, or as to the probable action of differences of pressure and temperature upon the gas contained within the body of the fish, I have lately, with the cooperation of M. Covelle, and in one of his aquaria, twice made an experiment, which on both occasions gave nearly identical results.

We gradually warmed the whole mass of water in the vessel, to see the effect of temperature upon the relative position of various fishes, some destitute of an air-bladder, others provided with such an organ either closed or possessing a communication with the exterior. The experiment was made upon bullheads (*Cottus gobio*), perch (*Perca fluviatilis*), tench

(*Tinca vulgaris*), gudgeons (*Gobio fluviatilis*), spirlins (*Alburnus bipunctatus*), and minnows (*Phoxinus lævis*). The first time we gradually raised the temperature of the water in two hours from 10° to 28° C. (from 50° to 82°·4 F.); the second time, in an hour and a half, from 9½° to 27° C. (from 49°·1 to 80°·6 F.).

The bullheads, which are without an air-bladder, never ceased to repose upon the gravel at the bottom; but after the temperature had been raised 6°–8° C. (10°·8–14°·4 F.), the perch, with their closed air-bladder, began to depart a little from the bottom, where they had at first remained nearly motionless. At the first moment the warming of the water gave rise to great agitation; but, the first surprise passed, quiet was restored, and we could then see all the fishes, except the bullhead, struggle with their fins to prevent their being carried towards the surface. As soon as the organs of motion were in repose, the animal rose more or less rapidly, like a balloon, without, however, appearing externally to be in the least inflated or deformed. The Cyprinidæ, furnished with an air-bladder having an external communication, ascended and descended alternately; and it seemed to me that the young struggled with more difficulty than the adults*. Some adult tench and a gudgeon in particular appeared much less influenced than some little tench, which were constantly being forced up towards the surface. At 22° C. (=71°·6 F.) one perch (from 7 to 10 centims., or from 3 to 4 inches long) kept about midwater in the aquarium; at 25° or 26° C. (77° or 78°·8 F.) they went willingly very near the surface; finally the head, being less elevated, was often turned more or less downwards. At 27° or 28° C. (=80°·6 or 82°·4 F.) the agitation again became general; several fishes appeared ready to perish; and we stopped the experiment, being unable to follow the action of the temperature upon creatures which were, so to speak, stupefied.

In the first experiment the introduction into the midst of the liquid of a vase of aquatic plants very rapidly restored quietude to the fishes which were agitated by an increasing suffocation. The second time we had fewer made ill, owing to our leaving a plant in the water during the whole experiment.

Although the fish, and especially those in which the air-

* This would seem to indicate that the capacity and importance of the air-bladder are greater in early youth than in the adult state; for we know that, in some fishes, the duct of communication with the exterior is rather obliterated with increasing age; and I have always remarked that the fins are comparatively larger in the young than in the old.

bladder is not closed, can evidently react more or less against slowly increasing differences of temperature or pressure, it is none the less probable that important diversities in pressure, and rapid or considerable changes of temperature, must have much influence upon the gestures of the individual under different conditions and in different seasons, and thereby more or less upon its external form and appearance*.

I may state, in passing, that in these two experiments we had the opportunity of ascertaining, in a very striking manner, that all the fishes heated (towards the end of January, when they were pale in colour) rapidly acquired, as the temperature increased, a much more brilliant coloration, somewhat analogous to the nuptial livery. The bullheads, which were at first whitish underneath, became almost black on the throat and belly; the perch and tench acquired very brilliant metallic reflections; the spirlins displayed a fine violet band at the upper part of the flanks; and the minnows already presented here and there on their lower surfaces the red coloration specially characteristic of the season of amours. When placed, after the experiment, in water at 9° or 10° C. (48°·2 or 50° Fahr.), these very rapidly lost all their temporary brilliancy.

Returning, now, to the consideration of fishes under normal conditions or in freedom, I may remark, first of all, that the species of the families with a mixed diet or omnivorous, and with an air-bladder in communication with the exterior, have always appeared to me more subject to vary, as to the form of the buccal organs or organs of prehension, than the fishes of exclusively animal or vegetable diet confined with them under the same conditions. Elsewhere, in another medium, it might be the latter that would vary most in this particular, or, perhaps, some other part would be called upon to vary first of all. A rule established upon such principles for one family will necessarily always be subject to apparent exceptions in another group.

Among other things we shall very speedily remark that *the plan of the modifications of the buccal cleft varies, in fishes, in diverse orders, even under similar conditions, according to the kind of gymnastic which may be permitted by other organs, such as the fins or the air-bladder.* The smelt, which takes

* It would be interesting to investigate, by a thorough study of all the gestures of the fish in different circumstances and at different seasons, why sometimes a certain species has a more or less developed air-bladder, whilst another, belonging to the same genus, is, on the contrary, destitute of that organ.

its food especially above it or at the surface of the water, will have the snout turned up and the mouth very oblique; while the sharks, which also most frequently hunt at the surface, will, on the contrary, in general have the mouth completely inferior. But in these two cases it is in the preponderant intervention of other organs that we must seek the explanation of the differences of modifications. The former of these fishes, with the organization of its fins, can with difficulty struggle against the influence of the air-bladder, which tends to retain it in the horizontal position; the latter, destitute of air-bladder, can, on the contrary, not only easily keep a portion of the head out of water, and the mouth open at the surface, but can also turn or twist in various directions, thanks to the arrangement of the organs of locomotion and the unequal development of the lobes of the caudal fin. I might select, nearer home, what may be called parallel examples, among the fishes which, in contrast to the above, live and hunt preferently at the bottom of the water. According as these are required to take their food most frequently from above, in front of, or beneath them, and according as the different developments of the air-bladder or the fins permit one position or another in the act of prehension, we shall usually see in them, with a slightly different situation of the eye, a more or less oblique arrangement of the buccal cleft, which is then superior, horizontal, or inferior. Compare, among others, in these respects, our goby, the bullhead, and our barbels.

It would not be difficult to multiply these examples, even in different classes; but I prefer still to limit myself in order now to compare fishes more similar to one another in form, and to establish here a parallel between various Cyprinidæ, leading different modes of life, and the various forms of one and the same species, according as the latter is subjected to one or another condition of existence. For this purpose I select a family all the members of which are equally provided with an air-bladder in communication with the exterior, and which consequently must be able to pass with more facility from one pressure to another.

If I compare, among others, our various representatives of the genera *Alburnus*, *Scardinius*, *Leuciscus*, *Abramis*, *Chondrostoma*, *Tinca*, *Carpio*, and *Barbus*, I see at once that to an habitual station more or less near the surface or the bottom of the water, there usually corresponds a more or less oblique arrangement of the buccal cleft, sometimes almost superior, sometimes completely inferior. I then remark that with a slightly different diet, most frequently necessitating the pre-

hension of food above, in front of, or beneath the individual, the form of the mouth also varies more or less in the fishes which generally live between these two extremes or in mid-water. Lastly, as corollaries of these first modifications dependent on habitat, I may recall the gradual apparition at the sides of the mouth, in our bottom-feeding Cyprinidæ, of tactile organs, more or less developed barbels. It must not be forgotten that, notwithstanding its constant communication with the exterior, the air-bladder, which is a little variable in position and proportions, may here exert an influence, up to a certain point, upon the general form of the fish and its mode of gymnastic, by pressing more or less against one part or another of the individual. Under the influence of the agents which superinduce the transformations of the mouth, we also see appear other correlative modifications in various parts of the animal—among others, in the greater or less declivity of the head, in the more or less convex or depressed form of the back and belly, in the variable compression of the sides, in the situation and proportions of the eye with regard to the forehead, and finally in the relative position and the development of certain fins.

These various tendencies to adaptation may be, I repeat, very different in other families, in which the equilibrium of the organism rests upon other foundations; or they may be accompanied by new modifications affecting other parts, such as the nature of the integuments for example.

Our barbel, which chiefly seeks its nourishment beneath it, on the bottom or in the mud, has the mouth opening below and furnished with barbels, the eye comparatively small, and the base of the anal fin rather short; the bleak, which, on the contrary, most frequently snatches its prey at the surface or above it, has the mouth oblique, opening more or less upwards, and destitute of barbels, with a large eye and the base of the anal fin comparatively elongated. The rudd and the roach, which most commonly seek their food at midwater, although the mouth is oblique in the former and quasi-horizontal in the latter, and without barbels in both, have nevertheless the anal and dorsal fins of nearly equal importance, and a body usually rather deeper than the species above indicated as inhabiting extreme situations. A certain resemblance of general form (which, however, is variable for each of these species in different media) may be due to a similitude of habitat in an average medium; but the examination of the grinding-plate and of the pharyngeal teeth betrays a marked preference for aliments of different natures, and consequently modes of prehension which are probably also somewhat diffe-

rent. The carp and the bream are recognizable at once by the great comparative basal extension of the dorsal in the former, and the anal in the latter. The carp, which keeps close to the bottom more constantly than the bream, possesses barbels, while these are wanting in the latter, which, on the other hand, has the two lobes of the caudal pretty constantly unequal.

The *Chondrostoma* ("nase") and the tench, which, in various points of view, constitute exceptions among our Cyprinidæ, show us here, again, new modifications in the organs relating to the mode of alimentation. Required generally to take its food from beneath it, the nase, like our barbel, has the mouth plainly inferior and the anal comparatively short; but, being destined to an almost exclusively vegetable diet, and accustomed rather to graze upon, than to rout up the bottom, it has no occasion for barbels; and its lips are instead furnished with a horny and trenchant sheath. Although willingly keeping at the bottom, the tench, which is more omnivorous than the carp and the barbel, and consequently requires to take its nourishment in more varied positions, shows at the same time a rather oblique mouth and a small lateral barbel; but in it the inferior fins are a little more powerful, and the eye, in order to look in different directions, possesses a mobility and a facility of projection which does not occur in any other of our Cyprinidæ.

It would require a very great number of comparative observations to determine to what degree of dependence each of these organs is subject, and which of them, under different circumstances, is first called upon to vary.

We might, I believe, push much further this comparative investigation, which I now only indicate in passing. The careful examination of the various dentitions, for example, has often shown me an intimate and very natural relation between the different forms of the teeth or of the pharyngeal plate, which betray the predominant nature of the diet, and a certain modification of the internal or external framework, in view of a peculiar gymnastic in the act of prehension.

Our bleak (*Alburnus lucidus*), being especially insectivorous, the habitual station of that fish, and the means of which it must make use in order to obtain such or such a prey of predilection, must vary, it would seem, with different conditions and circumstances, and thereby exert more or less influence upon the form of the mouth, the sole organ of prehension. In connexion with this I have observed that the majority of the bleak which inhabit certain of our rivers present a deeper or more compressed form of body, a less turned-up snout, and consequently a less oblique mouth than

most of those which live more habitually in some of our lakes. Now in our transparent lakes (the lake of Geneva for example) we may very often see these graceful little Cyprinidæ hunting in numerous bands, and snapping up right and left at the surface of the water the little insects of various sorts that the winds or other accidents beat down upon it daily; whilst we less frequently observe these fishes at the very surface in the moving, less transparent, shallower, and colder waters of several of our streams, such as the Rhine for example. It is difficult to avoid comparing these graceful little fishes with the active swallows, which, like the bleak, so often go in search of small insects close to the surface of the ground or over the mirror of our lakes. We may fairly ask whether meteorological influences, to a certain extent analogous with those which impel the swallows alternately towards the ground or the surface of the water, and to great altitudes in the air, may not also, in different media, present the bleak with their favourite food, according to circumstances, at the surface or at a lower level in the water.

According as the mouth, in order to adapt itself to the most habitual circumstances in a given medium, becomes more or less oblique, the back or the belly are, on the contrary, depressed or elevated, at the same time that the body becomes elongated or shortened.

Heckel's theoretical line, which passes through the extremity of the mouth and the middle of the caudal, displays these opposite deviations at the first glance, according as it passes at a greater or less height with respect to the centre of the eye and the summit of the back. The employment of this line may be equally valuable in showing the degree of certain deformations in fishes, as that of the two lines determining the facial angle in other animals; but it is a great pity that Heckel and, in imitation of him, several ichthyologists have too often attributed a specific value to the data obtained by this mode of mensuration.

It is easily understood that a modificatory influence like that of which I have just spoken, however minute it may be, but acting upon the individual from early youth, might in time, and by multiplying itself by reproduction, affect a species very profoundly under uncertain conditions.

The action of the deformatory agents already mentioned appears to me to be constant and regular enough; however, like every other rule, this also, I repeat, may present apparent exceptions, which a conscientious study of the circumstances and conditions of medium peculiar to each locality can alone satisfactorily explain.

It is always difficult to determine what is the preponderant influence, and consequently in what direction the first modifications will take place. I can easily understand the error of Blanchard, who has distinguished specifically, under the name of *Alburnus mirandella*, our elongated bleak of the lake of Geneva from the deeper ones of the French rivers. Nevertheless I cannot yet so easily explain the causes of the comparatively deeper form of the bleak which Heckel originally and erroneously distinguished under the name of *Alburnus lacustris* from the Neusiedler and Platten lakes, as I do not sufficiently know the nature and relative importance of the conditions of medium proper to those two lakes.

In fact the modificative and conservative agents opposed to each other may be of very diverse natures. Under influences of medium or local conditions we must include, in the case of our fishes, the depth of the medium, the degree of pressure, the transparency or the possible light, the surrounding temperature, the nature and origin of the water, the composition of the bottom, the faunas and floras of the region, the climate or the usual meteorological conditions of the locality, and, lastly, many other circumstances which are often difficult to appreciate.

I may here refer to the case of the *Leuciscus rutilus* of the Bruniger lake, of which I spoke in the number of the 'Bibliothèque' for September 1876, and which, in consequence of the retreat of the water of this little basin upon an almost entirely rocky bottom, was compelled to go to the surface in search of the vegetable and animal débris which were carried there by the winds. I stated that the body of this fish had by degrees become more elongated, with a very pale coloration, and that the mouth had acquired a more oblique position.

If I have dwelt so much upon this side of the variability of our fishes, and in particular of our bleak, it is because analogous cases, sometimes wrongly interpreted, also occur frequently in other genera, and have very often served for the establishment of numerous false species.

From all that has been stated, it would seem that we may derive, on the one hand, fresh proofs in support of the constant variability of the species under a concourse of favourable circumstances, and, on the other, the indication of certain limits imposed upon the modifications possible in a given direction under the influence of a peculiar, too predominant condition. In other words, it appears that in default of sufficient time, or of a relative equilibrium in the different influences of the medium, the series of correlative modifications cannot be effected in a durable manner, and that

from time to time we witness, as it were, a rupture or a recall to order which is sometimes fatal.

If an organ is too rapidly modified by a particular preponderant influence for the rest of the organism to follow it continuously in an equilibrate manner, it frequently happens, either that the progress of the variability is arrested in this first direction, or that the variety in course of formation is extinguished under these new conditions.

Nature, fortunately, is not so hasty as man in her requirements; she has had and still has ample time in which to work.

XLV.—*Descriptions of several African and Australian Lepidoptera in the Collection of the British Museum.* By Arthur G. Butler, F.L.S., F.Z.S., &c.

Four of the new species here described have recently been selected from a small collection, of great interest, made at Lake Nyassa by F. A. A. Simons. This collection was especially rich in two species of *Papilio* (*P. porthaon* of Hewitson, a butterfly new to the Museum series, and *P. nyassæ*, here described); there were also several forms of the difficult genus *Teracolus* (but chiefly identical with those from Natal), several species of *Acræa* (one of which will probably prove to be new to science), a few obscure little species of *Lycæna* and *Pamphila*, a little black-and-white *Liptena*?, and several very striking moths.

The Rockhampton collection contained (besides the beautiful Sphinges here described) several obscure forms of Noctuites and Crambites, an example of *Catopsilia hinda*, and other named species which were previously desiderata to the Museum.

Rhopalocera.

1. *Mycalesis Simonsii*, n. sp.

♂ ♀. Wings above sandy yellow, with a straight, transverse, pale-bordered, light brown postmedian line across both wings; costal and apical areas of primaries red-brown, particularly in the female, the base and outer border more or less tinted with the same colour; the margin and a submarginal line darker brown; two white-pupilled black ocelli, one small towards the apex, the other large between the first and second median branches: secondaries with six more or less strongly indicated discal black dots; outer margin red-brown; female with a slender submarginal red-brown line. Under surface